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Should the Development of Herbicide-tolerant Plants be a Focus of Sustainable Agriculture Research?

Should the development of herbicide-tolerant plants be a focus of sustainable agricultural research? According to an Environmental Protection Agency (EPA) publication from 1985, herbicides comprised roughly 60 percent of the pesticides used in the United States, about 500 million pounds of the roughly 860 million pounds of pesticides used annually in this country. Of these 860 million pounds of pesticides, including herbicides, estimates are that perhaps at most, 1 percent reach their target pests. The rest simply contaminate soil, water, crops, and farm workers.

What are the effects of this excessive use of herbicides^. Herbicides are designed to kill plants. Although there are a few exceptions, herbicides tend not to be acutely toxic to animals, that is, they generally do not have immediate toxic effects. A number of herbicides have, however, been implicated as chronic toxins, chemicals that have long-term health effects. Use of 2,4-D, for example, has been linked with non-Hodgkin's lymphoma in farmers and there is substantial evidence that Alachlor, the most heavily used herbicide on corn, is a carcinogen.

How does this effect us? The National Academy of Sciences estimated in a 1987 report that 31 percent of the oncogenic risks of pesticides on fresh foods is attributable to herbicides. But perhaps the most serious environmental effect of herbicides is the contamination of groundwater. Until the late 1970s, few thought that pesticides could possibly leach through soil into groundwater. When discussed, leaching was deemed virtually impossible. Then in the late 70s, the

insecticide Aldicarb was discovered in numerous wells on Long Island, and since then, the list of pesticides detected in groundwater has continued to grow. The EPA decided to compile the existing data on groundwater contamination in the United States, and their report was published in December 1988. The EPA has designated classes of pesticide detections ranging from those that are unconfirmed, where data is of unknown quality, to confirmed detections that are attributable to certain agricultural practices. In almost all confirmed cases of detection, groundwater contamination is due to agricultural use and a large percentage of the pesticides found are herbicides. Eight different pesticides have been detected in the groundwater in Iowa and the state with the most pesticides detected is New York, with twenty-one.

Two things make this contamination particularly scary. First, over 50 percent of the United States population depends on groundwater for drinking, and so are exposed to contaminants many times every day. Second, once contaminated, groundwater cannot generally be cleaned up.

HERBICIDE-TOLERANT PLANTS

Biotechnology has been touted as being able to do a lot things, from allowing us to create corn that fixes its own nitrogen, to creating crops that will save us from the drought and heat resulting from the greenhouse effect. But at least for now, researchers do not have the knowledge to fulfill many of these promises. Herbicide-tolerant plants, on the other hand, are an application of biotechnology that has become possible.

Herbicide-tolerant plants also have the potential to be tremendously profitable. It is no secret that most agricultural chemical companies now own seed companies, and the combined interest in seeds and herbicides could offer considerable financial rewards, especially when seeds promote the use of a herbicide that is already patented. If one believes the 1987 biotechnology newsletter, Agricultural Genetics Report, sales of herbicide-tolerant plants could come close to $6 billion a year by the turn of the century. Seeds that tolerate Roundup® could boost Monsanto's sales of this herbicide by $150 million. Seeds that tolerate the herbicide Basta—and plants which resist Basta® are about to be tested in Minnesota—would bring the German firm, Hoechst an additional $200 million in sales. Industry clearly recognizes this profit potential. The Rural Advancement Fund International in North Carolina has compiled a list from published sources, of institutions

doing research on herbicide-tolerant plants. They find that at least 21 enterprises have launched 68 research programs on herbicide- tolerant plants.

What are the environmental implications of all these herbicide- tolerant plants, if they are developed? There has been a lot of discussion about the risks of releasing genetically engineered organisms. It has been widely agreed among government officials, industry representatives, scientists, and environmentalists that the main risk of using herbicide-tolerant plants is that they may cross-pollinate with wild relatives and transfer genes conferring herbicide tolerance. This could increase the problems farmers have with herbicide-resistant weeds.

Most crops have few, if any, wild relatives with which they could hybridize in this country. Because most major crop plants in this country were imported from other continents, it is on these continents—primarily in Third World countries—that problems can be expected. Although gene transfer is a legitimate concern in this country, it is not a major concern.

EFFECTS OF HERBICIDE-TOLERANT PLANTS ON HERBICIDE USE

More of a concern than the risks of using herbicide-tolerant plants are the purposeful effects of herbicide-tolerant plants on herbicide use. Proponents of herbicide-tolerant plants argue that as more herbicide-tolerant crops are developed, farmers will be able to replace older, more dangerous chemicals with newer, more environmentally benign herbicides. The U.S. Department of Agriculgure (USDA) has granted many permits under the Plant Pest Act for field tests of herbicide-tolerant plants modified with recombinant DNA techniques. (Through a quirk of the law, the USDA only regulates field tests by plants modified with rDNA techniques, not plants modified with microprojectile techniques, cell cultures, or other methods.) Plants that resist three classes or types of herbicides have been field-tested; plants that resist glyphosate, bromoxynil, and the sulfonylureas. Advocates of herbicide-tolerant plants argue that glyphosate and bromoxynil degrade rapidly and that the sulfonylureas are used in such small quantities that they will have negligible harmful effects. Because these herbicides are toxic to most crops, herbicide-tolerant plants are needed to make these herbicides more useful. But, there are a number of problems with this argument. Most importantly, all the effects of these newer herbicides may not be acknowledged. Glyphosate, for example, is not acutely toxic to

mammals and is widely alleged to be safe, but it seems that in at least one of its chemical formulations, Monsanto's Roundup®, is acutely toxic to some fish, aquatic vertebrates, and, in very large dosages to humans. Glyphosate degrades quickly in most soil types, but glyphosate can persist in runoff water and be carried downstream. Although I have not seen the data, there is some evidence now that bromoxynil causes birth defects. Sulfonylurea chemicals are toxic to plants in minute quantities, and these herbicides do not degrade very quickly. Slight pesticide drift can have disastrous consequences for crops and native vegetation. In Franklin County, Oregon, for example, potatoes, carrots, fruit trees and other crops were damaged after the sulfonylurea herbicide Oust® was applied to roadsides in 1985. Local farmers subsequently went to court and won damages from the county and Du Pont, the herbicide's manufacturer. Farmers in Iowa are in a similar situation this summer. Numerous farmers used American Cyanamid's herbicide Sceptor® on soybeans last summer. Sceptor® is a modern herbicide that is toxic in very small quantities. Because of last summer's drought, the herbicide did not degrade and is now threatening corn planted in last year's soybean fields. American Cyanamid is funding research to develop crops that tolerate the imidazolinones, the class of herbicides that includes Sceptor®.

Even if newer herbicides are safer than older ones, they may still have significant undesirable effects. Should newer herbicides be promoted instead of developing products and practices that lessen or provide alternatives to herbicide use?

Work on herbicide tolerance is not limited to allegedly safe chemicals. According to a recent survey of publications by the Rural Advancement Fund International, crops are now being engineered to resist a number of herbicides that leach into groundwater, including Lexone®, Sencor®, Treflan®, and atrazine. Lexone®, Sencor®, and atrazine are listed by EPA as possible carcinogens, but because these plants pose no direct environmental or health risks, there is no mechanism for the public to have any influence over their development.

Proponents of herbicide-tolerant plants argue that newer herbicides are effective at lower application rates than other herbicides, so herbicide-tolerant plants could reduce the amount of herbicide needed for weed control. There are problems with this argument. In some circumstances, herbicide tolerance will clearly increase use. For example,

one of the major limiting factors on Atrazine application rates has been the problem of Atrazine carry-over. This new herbicide persists in the soil and damages the subsequent crops, such as soybeans and oats. If Atrazine-tolerant soybeans were developed, they could greatly increase the rate of Atrazine application on corn without damage to subsequent crops.

Herbicide tolerance may blunt the economically motivated reduction in herbicide use taking place on some farms. In recent years, some farms in the corn belt have shifted from broadcast application of herbicides—application on the entire field—to banding of herbicides—application just on crop rows. Weeds between rows can be easily controlled by mechanical cultivation. Even farmers who broadcast herbicides generally cultivate once, partly because herbicides rarely provide 100 percent weed control. If herbicide tolerance would allow farmers to gain 100 percent weed control without mechanical weeding, it would discourage the shift to banding.

Proponents of herbicide-tolerant plants also argue that herbicide-tolerant crops will give farmers a larger number of options for weed control. However, herbicide-tolerant plants may increase problems with herbicide-tolerant weeds through gene transfer and also through their effects on patterns of herbicide use. If herbicide-tolerant crops cause certain herbicides to become very widely used, weeds resistant to these herbicides are likely to evolve. Farmers will then not be able to use these herbicides even when they are legitimately needed, such as in integrated pest management programs.

WEED CONTROL RESEARCH FOR SUSTAINABLE AGRICULTURE

Herbicide-tolerant plants could cause substantial problems for agricultural and natural ecosystems, as well as human beings, and research on herbicide-tolerant plants should not be a part, and certainly not a focus, of sustainable agriculture research programs. What sort of weed control research should be supported as part of sustainable agriculture? Weed control measures that could lessen our dependence on herbicide use include crop rotation, cover crops, inner cropping, breeding crops to enhance allelopathy, timing tillage and planting to take better advantage of weed and crop germination times, engineering crops for increased cold tolerance so they emerge earlier, biological control with pathogens or insect herbivores, new integrated pest management strategies, and mechanical control.

One promising technique is ridge tillage. Ridge tillage is a cultivation method that reduces or eliminates the use of herbicides while retaining erosion control. Studies have shown that ridge tillage is about as effective as conservation tillage for erosion control. To use ridge tillage, a farmer builds a series of ridges and valleys across his or her fields. Crops are grown on the ridges and the wheels of farm equipment roll through the valleys. Once ridges are put into a field, they are permanent and do not have to be put in again. At spring planting time, a farmer goes through the field with his tractor and shaves off the top of the ridges. This removes any existing weeds and the seeds are then planted. As the plants emerge on the first cultivation, the farmer goes through again and cultivates by taking dirt off the top of the ridges and throwing it down in the valleys, which covers the weeds. On the last cultivation, the farmer takes dirt from the valleys, and throws it back up on the plants, again, to cover weeds and also rebuild the ridges. If herbicides are used in ridge tillage, their application can be reduced because it is easier to focus herbicide applications on ridges than with other techniques.

Ridge tillage is not for all farms. 11 does not work on sandy soil, but it is a good example of the kind of weed control options that should be researched and developed. Ridge tillage is not a panacea, but it is the sort of technique with which weed control strategies can be built.

OTHER USES OF HERBICIDE-TOLERANT PLANTS

Herbicide-tolerant plants could be developed for uses other than in conventional agriculture. Future homeowners, for example, might seed their lawns with herbicide-tolerant grass, and transportation officials might seed right-of-ways along roads and railroads corridors with herbicide-tolerant ground covers. Foresters may plant herbicide-tolerant trees in newly logged areas. Research to develop herbicide-tolerant trees is already underway.

Herbicides are used in forestry before and after tree seedlings are planted. Before tree seedlings are planted, newly logged areas are treated with herbicides to kill competing vegetation. After planting, herbicides are used to free commercially valuable trees from competition with other trees. At present, only a fraction of forests are aerially sprayed with herbicides. This fraction varies substantially with forest ownership, with forest terrain, and with the tree species harvested. The U.S. Forest Service sprays more often than small landowners.

Other methods to remove unwanted vegetation include mechanical control, injecting unwanted trees with herbicides, and burning. These other methods are relatively expensive. The Forest Service would like to increase herbicide spraying. Forest Service researchers believe that, "herbicide use would be more widespread and efficient if cultured tree species were immune or highly resistant to commonly-used herbicides". The biotechnology company Calgene and the Forest Service have produced, in a joint project, genetically engineered poplar trees that have limited tolerance to the herbicide Glyphosate®. The Forest Service is also planning a project to develop jack pine and poplar that tolerate the herbicides Hexazinone® and Glyphosate® respectively. This project is being done at the Forest Service's Rhinelander, Wisconsin Experiment Station using tissue culture techniques.

Herbicides can harm wildlife habitats, both by directly effecting the health of wildlife and also by changing plant community composition in forest areas. Uses of herbicide-tolerant trees could also effect the long-term productivity of forests. After clear cutting, tree seedlings are commonly planted six to fourteen feet apart. Pioneer vegetation, such as brambles, shrubs, and vines, grows rapidly over the newly-opened area and competes with tree seedlings. In a famous experiment at Hubbard Forest Research Station, scientists clear-cut a section of a watershed and prevented regrowth of plants with herbicides. Without pioneer plants to stabilize the soil, new plants were washed away and the quality of the site rapidly diminished. Clearly, if the use of herbicide- tolerant trees leads to similar suppression of pioneer vegetation, forests will deteriorate.

It is also ironic that the Forest Service is developing herbicide- tolerant trees at the same time as four Forest Service Management Regions and the Northwest Office of the Bureau of Land Management have prepared draft environmental impact statements (EIS) promoting reduction of herbicide use as the "preferred" alternative. These draft EISs, result of a lawsuit settlement, must consider the effect of vegetation management practices on natural ecosystems as well as timber production.

Herbicide-tolerant trees may make short-term economic sense for foresters, but designed as they are to increase herbicide use, they are incompatible with land stewardship. Using them in government forests would be a strong expression of timber primacy, the idea that forests are managed for timber production, not conservation and recreation.

CONCLUSIONS

The development of herbicide-tolerant plants is being advanced without constraint or enough adequate thought. Whether considering herbicide- tolerant trees or atrazine-resistant crops, herbicide-tolerant plants have the potential to increase our problems with these chemicals. This is not to say that there cannot be any benefits to herbicide-tolerant plants. It would certainly be better to have the farmers plant fields with herbicide-tolerant plants and treat them with Glyphosate® or sulfonylureas rather than plant them with non-resistant crops and treat with an herbicide known to contaminate ground water, such as Alachlor. But given alternative forms of weed control, it would be better to use weed control methods which minimize chemical use. Public sector funding could help the development of weed control alternatives that, unlike herbicide-tolerant plants, the industry has not found potentially profitable. After all, that is in large part why government research exists.

Government funding for sustainable agricultural research is limited. We should be investing these scarce dollars in techniques that, over the long haul, will change agriculture so that it does not degrade our environment or threaten human health.